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Low-temperature behavior of the Casimir free energy and entropy of metallic films

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Abstract

© 2017 American Physical Society. We derive an analytic behavior of the Casimir free energy, entropy, and pressure of metallic films in a vacuum at low temperature. It is shown that this behavior differs significantly depending on whether the plasma or the Drude model is used to describe the dielectric properties of film metal. For metallic films described by the lossless plasma model the thermal corrections to the Casimir energy and pressure drop to zero exponentially fast with increasing film thickness. There is no classical limit in this case. The Casimir entropy satisfies the Nernst heat theorem. For metallic films with perfect crystal lattices described by the Drude model, the Casimir entropy at zero temperature takes a nonzero value depending on the parameters of a film, i.e., the Nernst heat theorem is violated. The Casimir entropy at zero temperature is positive, as opposed to the case of two metallic plates separated with a vacuum gap, where it is negative if the Drude model is used. Possible applications of the obtained results in investigations of the stability of thin films are discussed.

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